

**In the Claims:**

1. (currently amended) A method of fabricating a semiconductor device, having a reduced-oxygen copper-zinc (Cu-Zn) alloy filled dual-inlaid interconnect structure formed on a copper (Cu) surface formed by electroplating the Cu surface in a chemical solution, comprising the steps of:
  - 5 providing a semiconductor substrate having a Cu surface formed in a via;
  - providing a chemical solution;
  - electroplating the Cu surface in the chemical solution thereby forming said a Cu-Zn alloy fill in the via and on the Cu surface,
  - wherein said electroplating comprises using an electroplating apparatus,
  - 10 wherein said electroplating apparatus comprises:
    - (a) a cathode-wafer;
    - (b) an anode;
    - (c) electroplating vessel; and
    - (d) a voltage source, and
  - 15 wherein the cathode-wafer comprises the Cu surface,
  - rinsing the Cu-Zn alloy fill in a solvent;
  - drying the Cu-Zn alloy fill under a gaseous flow;
  - annealing the Cu-Zn alloy fill formed in the via and directly deposited on the Cu surface,
  - thereby forming a reduced-oxygen Cu-Zn alloy fill having an alloy surface and
  - 20 an alloy thickness and having a uniform zinc distribution across said alloy surface
  - and said alloy thickness;
  - planarizing the reduced-oxygen Cu-Zn alloy fill and the Cu surface, thereby completing
  - formation of a reduced-oxygen Cu-Zn alloy filled dual-inlaid interconnect
  - structure; and
  - completing formation of the semiconductor device.

2. (original) A method, as recited in Claim 1,  
wherein the chemical solution is nontoxic and aqueous, and  
wherein the chemical solution comprises:
  - 5 at least one zinc (Zn) ion source for providing a plurality of Zn ions;
  - at least one copper (Cu) ion source for providing a plurality of Cu ions;
  - at least one complexing agent for complexing the plurality of Cu ions;
  - at least one pH adjuster;
  - at least one wetting agent for stabilizing the chemical solution, all being dissolved  
in a volume of deionized (DI) water.
  
3. (original) A method, as recited in Claim 2,  
wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected  
from a group consisting essentially of zinc acetate ((CH<sub>3</sub>CO<sub>2</sub>)<sub>2</sub>Zn), zinc bromide  
(ZnBr<sub>2</sub>), zinc carbonate hydroxide (ZnCO<sub>3</sub>·2Zn(OH)<sub>2</sub>), zinc dichloride (ZnCl<sub>2</sub>),  
5 zinc citrate ((O<sub>2</sub>CCH<sub>2</sub>C(OH)(CO<sub>2</sub>)CH<sub>2</sub>CO<sub>2</sub>)<sub>2</sub>Zn<sub>3</sub>), zinc iodide (ZnI<sub>2</sub>), zinc L-  
lactate ((CH<sub>3</sub>CH(OH)CO<sub>2</sub>)<sub>2</sub>Zn), zinc nitrate (Zn(NO<sub>3</sub>)<sub>2</sub>), zinc stearate  
((CH<sub>3</sub>(CH<sub>2</sub>)<sub>16</sub>CO<sub>2</sub>)<sub>2</sub>Zn), zinc sulfate (ZnSO<sub>4</sub>), zinc sulfide (ZnS), zinc sulfite  
(ZnSO<sub>3</sub>), and their hydrates.
  
4. (original) A method, as recited in Claim 2,  
wherein the at least one copper (Cu) ion source comprises at least one copper salt  
selected from a group consisting essentially of copper(I) acetate (CH<sub>3</sub>CO<sub>2</sub>Cu),  
copper(II) acetate ((CH<sub>3</sub>CO<sub>2</sub>)<sub>2</sub>Cu), copper(I) bromide (CuBr), copper(II) bromide  
5 (CuBr<sub>2</sub>), copper(II) hydroxide (Cu(OH)<sub>2</sub>), copper(II) hydroxide phosphate  
(Cu<sub>2</sub>(OH)PO<sub>4</sub>), copper(I) iodide (CuI), copper(II) nitrate ((CuNO<sub>3</sub>)<sub>2</sub>), copper(II)  
sulfate (CuSO<sub>4</sub>), copper(I) sulfide (Cu<sub>2</sub>S), copper(II) sulfide (CuS), copper(II)  
tartrate ((CH(OH)CO<sub>2</sub>)<sub>2</sub>Cu), and their hydrates.
  
5. (previously canceled)

6. (previously amended) A method, as recited in Claim 1,  
wherein the anode comprises at least one material selected from a group consisting  
essentially of copper (Cu), a copper-platinum alloy (Cu-Pt), titanium (Ti),  
platinum (Pt), a titanium-platinum alloy (Ti-Pt), an anodized copper-zinc alloy  
5 (Cu-Zn, i.e., brass), a platinized titanium (Pt/Ti), and a platinized copper-zinc  
(Pt/Cu-Zn, i.e., platinized brass).
7. (original) A method, as recited in Claim 1,  
wherein said semiconductor substrate further comprises a barrier layer formed in the via  
under said Cu surface, and  
wherein the barrier layer comprises at least one material selected from a group consisting  
5 essentially of titanium silicon nitride ( $Ti_xSi_yN_z$ ), tantalum nitride (TaN), and  
tungsten nitride ( $W_xN_y$ ).
8. (original) A method, as recited in Claim 7,  
wherein said semiconductor substrate further comprises an underlayer formed on the  
barrier layer,  
wherein said underlayer comprises at least one material selected from a group consisting  
5 essentially of tin (Sn) and palladium (Pd), and  
wherein said Cu surface is formed over said barrier layer and on said underlayer.
9. (original) A method, as recited in Claim 8,  
wherein said underlayer comprises a thickness range of approximately 15 Å to  
approximately 50 Å,  
wherein said barrier layer comprises a thickness range of approximately 30 Å to  
5 approximately 50 Å,  
wherein said Cu surface comprises a thickness range of approximately 50 Å to  
approximately 70 Å, and  
wherein said Cu-Zn alloy fill comprises a thickness range of approximately 300 Å to  
approximately 700 Å.

10. (original) A method, as recited in Claim 1,  
wherein the annealing steps are performed in a temperature range of approximately  
150°C to approximately 450°C, and  
wherein the annealing steps are performed for a duration range of approximately 0.5  
5 minutes to approximately 60 minutes.
11. (currently amended) A semiconductor device, having a reduced-oxygen copper-zinc (Cu-  
Zn) alloy filled dual-inlaid interconnect structure formed on a copper (Cu) surface formed  
by electroplating the Cu surface in a chemical solution, fabricated by a method  
comprising the steps of:  
5 providing a semiconductor substrate having a Cu surface formed in a via;  
providing a chemical solution;  
electroplating the Cu surface in the chemical solution, thereby forming a Cu-Zn  
alloy fill in the via and on the Cu surface;  
wherein said electroplating comprises using an electroplating apparatus,  
10 wherein said electroplating apparatus comprises:  
(a) a cathode-wafer;  
(b) an anode;  
(c) electroplating vessel; and  
(d) a voltage source, and  
15 wherein said cathode-wafer comprises the Cu surface,  
rinsing the Cu-Zn alloy fill in a solvent;  
drying the Cu-Zn alloy fill under a gaseous flow;  
annealing the Cu-Zn alloy fill formed in the via and directly deposited on the Cu surface,  
thereby forming a reduced-oxygen Cu-Zn alloy fill having an alloy surface and  
20 an alloy thickness and having a uniform zinc distribution across said alloy surface  
and said alloy thickness;  
planarizing the reduced-oxygen Cu-Zn alloy fill and the Cu surface, thereby completing  
formation of a reduced-oxygen Cu-Zn alloy filled dual-inlaid interconnect  
structure; and  
25 completing formation of the semiconductor device.

12. (original) A device, as recited in Claim 11,  
 wherein the chemical solution is nontoxic and aqueous, and  
 wherein the chemical solution comprises:
- at least one zinc (Zn) ion source for providing a plurality of Zn ions;
  - at least one copper (Cu) ion source for providing a plurality of Cu ions;
  - at least one complexing agent for complexing the plurality of Cu ions;
  - at least one pH adjuster;
  - at least one wetting agent for stabilizing the chemical solution, all being dissolved  
 in a volume of deionized (DI) water.
13. (original) A device, as recited in Claim 12,  
 wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected  
 from a group consisting essentially of zinc acetate ( $(\text{CH}_3\text{CO}_2)_2\text{Zn}$ ), zinc bromide  
 ( $\text{ZnBr}_2$ ), zinc carbonate hydroxide ( $\text{ZnCO}_3 \cdot 2\text{Zn}(\text{OH})_2$ ), zinc dichloride ( $\text{ZnCl}_2$ ),  
 zinc citrate ( $\text{O}_2\text{CCH}_2\text{C}(\text{OH})(\text{CO}_2\text{CH}_2\text{CO}_2)_2\text{Zn}_3$ ), zinc iodide ( $\text{ZnI}_2$ ), zinc L-lactate  
 ( $(\text{CH}_3\text{CH}(\text{OH})\text{CO}_2)_2\text{Zn}$ ), zinc nitrate ( $\text{Zn}(\text{NO}_3)_2$ ), zinc stearate  
 ( $(\text{CH}_3(\text{CH}_2)_{16}\text{CO}_2)_2\text{Zn}$ ), zinc sulfate ( $\text{ZnSO}_4$ ), zinc sulfide ( $\text{ZnS}$ ), zinc sulfite  
 ( $\text{ZnSO}_3$ ), and their hydrates.
14. (original) A device, as recited in Claim 12,  
 wherein the at least one copper (Cu) ion source comprises at least one copper salt  
 selected from a group consisting essentially of copper(I) acetate ( $\text{CH}_3\text{CO}_2\text{Cu}$ ),  
 copper(II) acetate ( $(\text{CH}_3\text{CO}_2)_2\text{Cu}$ ), copper(I) bromide ( $\text{CuBr}$ ), copper(II) bromide  
 ( $\text{CuBr}_2$ ), copper(II) hydroxide ( $\text{Cu}(\text{OH})_2$ ), copper(II) hydroxide phosphate  
 ( $\text{Cu}_2(\text{OH})\text{PO}_4$ ), copper(I) iodide ( $\text{CuI}$ ), copper(II) nitrate hydrate ( $(\text{CuNO}_3)_2$ ),  
 copper(II) sulfate ( $\text{CuSO}_4$ ), copper(I) sulfide ( $\text{Cu}_2\text{S}$ ), copper(II) sulfide ( $\text{CuS}$ ),  
 copper(II) tartrate ( $(\text{CH}(\text{OH})\text{CO}_2)_2\text{Cu}$ ), and their hydrates.
15. (previously canceled)

16. (previously amended) A device, as recited in Claim 11,  
wherein the anode comprises at least one material selected from a group consisting  
essentially of copper (Cu), a copper-platinum alloy (Cu-Pt), titanium (Ti),  
platinum (Pt), a titanium-platinum alloy (Ti-Pt), an anodized copper-zinc alloy  
(Cu-Zn, i.e., brass), a platinized titanium (Pt/Ti), and a platinized copper-zinc  
(Pt/Cu-Zn, i.e., platinized brass).
17. (original) A device, as recited in Claim 11,  
wherein said semiconductor substrate further comprises a barrier layer formed in the via  
under said Cu surface, and  
wherein the barrier layer comprises at least one material selected from a group consisting  
essentially of titanium silicon nitride ( $Ti_xSi_yN_z$ ), tantalum nitride (TaN), and  
tungsten nitride ( $W_xN_y$ ).
18. (original) A device, as recited in Claim 17,  
wherein said semiconductor substrate further comprises an underlayer formed on the  
barrier layer,  
wherein said underlayer comprises at least one material selected from a group consisting  
essentially of tin (Sn) and palladium (Pd), and  
wherein said Cu surface is formed over said barrier layer and on said underlayer.
19. (original) A device, as recited in Claim 18,  
wherein said underlayer comprises a thickness range of approximately 15 Å to  
approximately 50 Å,  
wherein said barrier layer comprises a thickness range of approximately 30 Å to  
approximately 50 Å,  
wherein said Cu surface comprises a thickness range of approximately 50 Å to  
approximately 70 Å, and  
wherein said Cu-Zn alloy fill comprises a thickness range of approximately 300 Å to  
approximately 700 Å.

20. (original) A semiconductor device, having a first interim reduced-oxygen copper-zinc (Cu-Zn) alloy fill formed on a copper (Cu) surface and a second interim reduced-oxygen Cu-Zn alloy fill formed on a Cu-fill, both films being formed by electroplating the Cu surface and the Cu-fill, respectively, in a chemical solution, comprising:
- 5 a semiconductor substrate having a via; and  
an encapsulated dual-inlaid interconnect structure formed and disposed in said via, said interconnect structure comprising:
- at least one Cu surface formed in said via;  
a first interim reduced-oxygen Cu-Zn alloy fill formed and disposed on the at  
10 least one Cu surface;  
a Cu-fill formed and disposed on said interim reduced-oxygen Cu-Zn alloy fill;  
and  
a second interim reduced-oxygen Cu-Zn alloy fill formed and disposed on the Cu-fill.